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Broadcast of Calls of the Northern Goshawk : Their Effectiveness and Their Use in Inventory and Long-Term Monitoring Programs

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BROADCAST OF CALLS OF THE NORTHERN GOSHAWK:

THEIR EFFECTIVENESS AND THEIR USE IN INVENTORY AND LONG-TERM MONITORING PROGRAMS

by

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CHAPTER 1

RESPONSIVENESS OF NORTHERN GOSHAWKS TO BROADCAST OF THREE CONSPECIFIC CALLS

Modern forestry practices such as selective (individual tree), overstory removal, or patch and clear-cut harvesting, which result in either a complete removal of trees or in a reduction of the stem density and canopy volume throughout management units, threaten northern goshawk (*Accipiter gentilis*) nesting habitat (Reynolds 1989). To reduce the loss of nesting habitat, managers need to identify existing nesting stands and withdraw these stands from planned treatments.

Locating nest sites of the northern goshawk can be a very time-consuming process because so many potential nest trees are available. Forest-dwelling hawks, including accipiters, in the eastern U.S. respond to tape broadcasts of conspecific vocalizations (Fuller and Mosher 1981, Rosenfield et al. 1985, 1988, Kimmel and Yahner in press), which help localize the search area for a nest. Rosenfield et al. (1988) quantified the effectiveness of broadcast vocalizations in locating Cooper's hawk (*A. cooperii*) nests in Wisconsin. They found that during the nestling stage broadcast of the Cooper's hawk alarm call (*ca-ca-ca-ca*) (Palmer 1988) markedly increase the chance of finding these hawks near their nests.

Kimmel and Yahner (in press) found that northern goshawks near their nests in Pennsylvania are significantly more responsive to tape broadcasts of their own alarm call (*keck-keck-keck*) than to the territorial song of a great horned Owl (*Bubo virginianus*). However, they did not use controls (transects with an observer without vocalizations) so the increased detectability of nesting northern goshawks with broadcast vocalizations cannot be evaluated from their study results.

Studies testing the effectiveness of broadcast vocalizations for detecting accipiters have used the alarm call as the conspecific vocalization. The effectiveness of other accipiter vocalizations for detecting nesting accipiters has not been tested. In addition, none of the broadcast vocalization studies have examined the probability of "false positives" resulting from taped broadcasts of raptor vocalizations. Many of the corvids, e.g., Steller's jays (*Cyanocitta stelleri*), will mimic raptor calls and could be confused by an inexperienced observer as a raptor response to a taped broadcast.

One objective of this study was to experimentally test the effectiveness of 3 northern goshawk vocalizations in detecting nesting northern goshawks. We evaluated 1) the effect of breeding season period and distance from the nest on response rate and the number of false positives resulting from each type of vocalization. The results of this experiment are presented in this chapter (Chapter 1).

A second objective of this study was to use the results of this experiment combined with the results of other studies on broadcast

vocalization surveys to design an inventory protocol for locating northern goshawk nests in Region 3 of the U.S. Forest Service. This protocol is presented in Chapter 2. During the course of the study it became apparent that a protocol for monitoring the long-term occupancy of northern goshawk territories was also necessary to track the status of the population in the southwest. This monitoring protocol is presented in Chapter 3.

STUDY AREAS

We conducted trials at 27 occupied northern goshawk territories in New Mexico and Arizona during the spring and summer of 1990. Six study territories were in the Jemez Mountains of north-central New Mexico (this area is described in Kennedy 1988) and 21 territories were in the Kaibab Plateau of north-central Arizona (this area is described in Crocker-Bedford and Chaney 1988). Four New Mexico and 19 Arizona territories were in forests dominated by ponderosa pine (*Pinus ponderosa*); the remaining 4 territories, 2 in each study area, were in mixed conifer forests dominated by Douglas fir (*Pseudotsuga menziesii*) and white fir (*Abies concolor*). Nesting stands in both study areas were typically dominated by large, old growth trees (Kennedy 1988, Crocker-Bedford and Chaney 1988). Many of the nest sites used in this study were located in those earlier studies (Kennedy 1988, Crocker-Bedford and Chaney 1988).

METHODS

In April 1990 (courtship) we visited 8 New Mexico and 23 Arizona nest sites to assess occupancy. All of the Arizona and 3 of the New Mexico territories were known to have been occupied in 1989 (Kennedy unpubl. data, Arizona Department of Game and Fish unpubl. data). The remaining New Mexico nest sites had been used at least once between 1985 and 1989. We heard and/or saw adult goshawks in 17 sites (NM = 4, AZ = 13), and found new greenery on nests at 7 additional sites (NM = 4, AZ = 3). Based on these observations of nest attentiveness, we established transects near 5 New Mexico and 17 Arizona nests. Transects were placed near the 1989 nest unless there was evidence that a different nest was to be used in 1990. Transects were added at 4 additional Arizona territories (located during 1990 Arizona Game and Fish Department surveys) in the nestling (June N = 3) and fledgling-dependency periods (August N = 1) and at one additional New Mexico territory during the nestling period (June N = 1).

Transects were 800-m in length, consisted of 8 stations separated by 100 m and were located so that the last station was 100 m (perpendicular) from the nest (Figure 1). The farthest station was 700 m from the closest station and 707 m from the nest (Figure 1). All distances were paced estimates. Transects were located perpendicular to the nest rather than directly in line with the nest to more accurately simulate survey conditions.

Broadcast calls were tested during 3 stages of the northern goshawk breeding cycle: courtship (April), nestling (June), and fledgling-dependency (July-August) periods. We tested: 1) the alarm

call, which is given by both adults during the nesting season and is directed towards a conspecific intruder or potential predator; 2) the wailing call, which is given by both adults, predominantly the female, and appears to be a means of communication between pair members (Palmer 1988); and 3) the begging vocalizations of the fledglings. The begging call of the fledglings resembles a high-pitched version of the female's "recognition scream" when the male appears in the nest area. Both the wail and begging calls are one-note calls and have remote gull-like qualities (Palmer 1988).

We conducted control (an observer walking the transect but not playing taped broadcasts) transects first during each sampling period. We tested the alarm call during each sampling period, added the wail call during the nestling period, and the juvenile begging call during the fledgling period for a maximum of 9 trials (3 controls and 6 broadcast trials) conducted at each nest. The total number of transects conducted at each nest varied depending upon the time the transect was established. The order of broadcast trials was randomized during the nestling and fledgling trials. A total of 215 transects (68 controls and 147 broadcast trials) were conducted at the 27 northern goshawk nests during the study.

All calls were recorded on 10 second loop tapes for the broadcast trials. The alarm call was recorded from commercial recordings of bird vocalizations. The wail and begging calls were recorded at nests in the Jemez Mountains. We used a Panasonic FW18 portable cassette player that had the output frequencies and output power recommended for censusing woodland raptors with broadcast vocalization surveys (Devaul 1989). Although we did not test the acoustic properties of the broadcasts, we know that one goshawk vocally responded to tapes played with this recorder from 600 m.

Kimmel and Yahner (in press) found that time of day did not influence the response rate of northern goshawk so we conducted tests between one half hour before sunrise and sunset. Testing was discontinued when winds exceeded 25 km/hr (Beaufort scale of 4). We utilized a single observer (DWS) in all trials to eliminate observer variability. The observer also had measured and marked the transects, so he knew the nest locations. During the experiments, he minimized this bias by purposefully and systematically looking and listening in all directions at each station during all trials.

The broadcast technique we used at each station was a modification of the technique used by Rosenfield et al. (1988). At each station during a broadcast trial, the call was broadcast at 60^{0} (from his travel route) for 10 sec, 180^{0} for 10 sec, and then at 300^{0} for 10 sec for a total initial broadcast of 30 sec. The observer then looked and listened for 30 sec and repeated this cycle broadcasting in each direction for 10 sec with 30 sec listening periods between broadcasts. During a control he mimicked his movements during a broadcast trial but did not play a tape. The total time the observer spent at each station was 3 minutes.

When a goshawk was detected, the observer recorded the station at which the response was detected, the start and end time of the response,

the age and sex of the responding bird, and the response type (vocal only, vocal and approach, silent approach, approach and vocalize). A trial was completed when a goshawk response was recorded.

We also recorded the number of northern goshawk mimic calls given jays (Corvidae) during the transects. Because we were only interested in the number of false positives and not all mobbing responses to northern goshawk vocalizations, we only recorded kecking, wailing and begging vocalizations produced by jays that were not accompanied by a visual detection of the mimic.

STATISTICAL ANALYSES

Transect data collected at unsuccessful nests (15 nests, 93 transects) during the nestling (39 transects) and fledgling-dependency periods (54 transects) were separated from transects conducted at successful nests (12 nests, 122 transects) during those 2 sampling periods. Because all sample nests were assessed as active during courtship, data from this sample period were included in the database on successful nests. Response rates were expressed as the frequency of responses and as the percent response (number of responses divided by the total number of transects). Differences in the number of goshawk responses as a function of experimental factors were tested for both successful and unsuccessful nests using Chi-square analyses with the FREQ procedure in the statistical package SAS (SAS Institute Inc 1989). Chi-square analyses were also used to test for differences in the number of false positives (goshawk mimics) as a function of experimental factors. The significance level was $\underline{P} = 0.05$ for all tests.

RESULTS

Northern goshawk responses to taped conspecific calls were detected on 59 of 81 (72.8%) broadcast transects conducted at successful nests. This was significantly higher than the response rate of northern goshawk at successful nests to an observer without a tape (control) (14 of 41 transects, 34.1%) ($\chi^2 = 16.96$, df = 1, $P < 0.05$). At unsuccessful nests, northern goshawk responses to taped conspecific calls were detected on only 13 of 66 (19.7%) broadcast transects, and on only 1 of 26 (3.8%) controls. The data collected at unsuccessful nests could not be tested statistically because > 25% of the cells had expected counts less than 5 (Sokal and Rohlf 1981).

Behavior of northern goshawks responding to taped calls ranged from silent approach to approach with vocalizations. Sixty-nine of the 73 (94.5%) detectable responses on control and tape broadcast transects conducted at successful nests included vocalizations. The vocal responses without any approach by a northern goshawk to the station (68.5% of responses) included kecking or wailing by adults, and kecking, wailing or begging by fledglings. Vocalizations followed by an approach by the hawk and silent approaches by the hawk followed by vocalizations occurred in 19 of 73 (26.0%) of the detectable responses at successful nests. Silent approaches occurred in 4 of 73 (5.5%) detectable responses at successful nests.

The age class of the responding northern goshawk was identified in 83 of the 87 (95.4%) detectable responses recorded at both unsuccessful and successful nests (pooled over all transect types). Adult females made 62.7% of the age classed responses, adult males made 6.0% of the age classed response, and adults of unknown sex made 2.4% of the age classed responses. Fledglings (both sexes) made 37.3% of the age classed responses (for responses pooled over all sampling periods). During the fledgling-dependency period, 32 of the 43 responses (74.4%) were made by fledglings.

Effects of Experimental Factors. Using data pooled over all types of vocalizations, the response rate of northern goshawks to tape broadcasts was not significantly different from the response rate on controls during courtship (^{2} = 2.64, df = 1, P > 0.05) and the fledgling-dependency period (^{2} = 3.75, df = 1, P > 0.05). However, the response rate to broadcasts (19 of 26, 73.1%) was significantly higher than the response rate on controls (2 of 12, 16.7%) (^{2} = 10.57, df = 1, P < 0.05) during the nestling period. Although the data from unsuccessful nests could not be examined statistically, the response rates of northern goshawks at unsuccessful nests were similar between the nestling (5 of 39, 12.8%) and fledgling-dependency (7 of 54, 13%) periods.

Response rates of northern goshawks to the 3 types of conspecific calls (data from all sampling periods combined) were not significantly different (^{2} = 2.26, df = 2, P > 0.05) (Figure 2A). The 3 types of tape broadcasts resulted in response rates ranging from 65.9% (kecking) to 84.6% (begging). During the nestling period, response rates to the alarm call (keck) (12 of 13 transects, 92.3%) were greater than the response rates to the wail call (7 of 13 transects, 53.9%) or to the control (2 of 13 transects, 15.4%) (Figures 2C and 3). The northern goshawk response rate to taped vocalizations was not significantly different from their response rate to controls when data were pooled for all vocalization types during the fledgling-dependency period. The response rates ranged from 38.5% (5 of 13 transects) for the alarm call to 84.6% (11 of 13 transects) for the begging call and 100% (13 of 13 transects) for the wailing call (Figures 2D and 3). These frequencies could not be tested statistically because > 25% of the cells had expected values < 5.

At unsuccessful nests, the response rate was highest for the alarm call. However, none of the taped vocalizations produced significantly higher response rates during either the nestling or fledgling-dependency periods at unsuccessful nests (Figure 4).

The median distance at which responses were detected (pooled over all transect types) was 141 m from the nest during the nestling period (Figure 5C), the fledgling-dependency period (Figure 5D) and for data pooled over all sampling periods (Figure 5A). The median detection distance for all transect types during courtship was 224 m from the nest (Figure 4B). Almost all of the responses for all sample periods (91.7% Figure 5A) and all responses during the nestling period (Figure 5C) were detected within 316 m of the nest.

Response Rates of Goshawk Mimics. Steller's jays were detected on 70 of the 215 (32.6%) transects and 51.4% (36 transects) of these detections were vocal mimics of goshawk calls. Therefore, the percent of false positives was 16.7%. The frequency of mimics on control transects (7 of 61, 10.3%) was not significantly different from the frequency of mimics on vocalization transects (29 of 118, 19.7%) at all nests (^{2} = 2.97, df = 1, $P > 0.05$) and at successful nests (^{2} = 1.79, df = 1, $P > 0.05$).

The response rate of mimics at successful nests (pooled over all transects) was significantly different between sampling periods (^{2} = 6.68, df = 2, $P > 0.05$) (Figure 6). The highest mimicry rates occurred during courtship (25.8%) and the fledgling-dependency period (24.5%). while the lowest mimicry rates occurred during the nestling period (5.3%). Within sample periods, the rate of mimicry for each tape broadcast was similar (Figure 6). For data pooled over all sample periods the mimicry rates were 14.8% for the wail call, 24.4% for the keck call, and 30.8% for the begging call (Figure 6A). These data could not be analyzed statistically because the expected counts were < 5 in > 25% of the cells.

DISCUSSION

Our results support the conclusions of Marion et al. (1981), Fuller and Mosher (1981), Rosenfield et al. (1988), and Kimmel and Yahner (in press) that taped calls are useful for facilitating censuses of elusive and secretive birds such as the northern goshawk. Because censuses of accipiters are best conducted during the breeding season when they typically defend their nesting territory (Reynolds 1982), the use of taped calls can markedly increase the chance of detecting of northern goshawks at their nests.

Detection rates with broadcast tapes of northern goshawks in our study were highest during the nestling period. We did not evaluate the effectiveness of taped vocalizations during incubation because Rosenfield et al. (1988) had higher detection rates of nesting Cooper's hawks with vocalizations during the nestling period than during incubation. Fuller and Mosher (1981) state that raptors respond less to tape broadcasts during incubation because most respondents are females, and females are less likely to leave eggs then nestlings or fledglings. Kimmel and Yahner (in press) found no significant differences in response rate of northern goshawks to conspecific calls or owl calls during the nestling and fledgling-dependency periods. However, their results are difficult to interpret because they did not have controls.

Each of the 3 conspecific calls tested in this study had high rates of detectability when data were pooled over all sample periods. However, we recommend surveying with the kekking call during the nestling period because it elicited the highest response rate during the only period when the response rates to taped vocalizations were significantly different from controls. Kimmel and Yahner (in press) also recommended using this vocalization because in their comparisons it resulted in significantly higher detection rates of northern goshawks

during both the nestling and fledgling-dependency periods than did great horned owl vocalizations.

Response rates for northern goshawks during the fledgling-dependency period were not significantly different between taped vocalizations and controls in part because juveniles are normally vocalizing extensively during this period in an effort to find food. We do not recommend tape broadcast surveys at this time because it is more important to survey during the nestling period, which is earlier during the breeding season and fewer nests will have failed. Surveys conducted during the nestling period should result in the maximum number of nests being located per unit time. However, playback of wail or begging calls during the fledgling-dependency period can be used to augment nest search efforts conducted during the nestling period or to estimate productivity of the successful nests.

As with previous studies of nesting accipiters (Rosenfield et al. 1988, Kimmel and Yahner in press), we found that a majority of adult northern goshawks at successful nests may be detected when conspecific calls are broadcast within 150-200 m of nests. Therefore, if a complete census of breeding pairs in a prescribed area is desired, Kimmel and Yahner's (in press) recommendations for censusing northern goshawks in the eastern U. S. can be applied to southwestern populations. They recommend that transects be spaced no more than 300 m apart and that taped calls be played at broadcast stations spaced every 150-200 m along transects.

Adult northern goshawks at unsuccessful nests did not respond significantly more to vocalizations than to controls and there were fewer responses than no responses. This low response rate for unsuccessful nests supports Kimmel and Yahner's (in press) prediction that surveys conducted late in the nesting season might underestimate the number of breeding territories. However, 11 responses to 66 taped broadcasts conducted at unsuccessful nests did occur. Ten of these respondents were adult females. If we assume these respondents were the territory occupants and not foraging birds from other territories, these results suggest that some unsuccessful females remain near their nest sites or visit these sites regularly throughout the summer. Areas where adult northern goshawks respond to tapes but no active nests can be located might represent an unsuccessful territory.

Northern goshawk mimicry by jays might lead inexperienced observers to overestimate the number of northern goshawk territories in an area by 10-20% if they cannot distinguish mimics from actual goshawk vocalizations. Although we did not detect Cooper's hawk responses in this study, their vocalizations during a survey is another potential source of error for an inexperienced observer.

Our tests of the effectiveness of 3 northern goshawk calls confirmed the results of other taped broadcast studies (Fuller and Mosher 1981, Rosenfield et al. 1988, Kimmel and Yahner in press) that the most effective broadcast survey method for detecting nesting accipiters is to use the alarm call during the nestling period. Intensive broadcast surveys during this 6-week period, coupled with

stratification of habitats using a predictive habitat model, should be an efficient and effective technique for surveying large areas for nesting northern goshawk and perhaps for other woodland raptors.

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CHAPTER 2

A SURVEY PROTOCOL FOR NORTHERN GOSHAWKS NESTS IN THE SOUTHWEST

Identifying the nesting stands of forest-dwelling raptors such as the northern goshawk, is a very time-consuming process because so many potential nest trees are available. Forest-dwelling hawks in the eastern U.S. have responded to tape broadcasts of conspecific vocalizations (Fuller and Mosher 1981, Rosenfield et al. 1985, 1988, Kimmel and Yahner in press), which helped to localize the search area for a nest. Rosenfield et al. (1988) quantified the effectiveness of broadcast vocalizations in locating Cooper's hawk nests in Wisconsin. They found that during the nestling stage, broadcast of the Cooper's hawk alarm call (*ca-ca-ca-ca*) markedly increased the chance of finding these hawks near their nests. Kimmel and Yahner (in press) found that northern goshawks near their nests in Pennsylvania responded significantly more to tape broadcasts of their own alarm call (*keck-keck-keck*) than to the territorial call of a great horned owl.

We have utilized broadcast vocalizations of adult alarm and recognition calls and fledgling food-begging calls to locate northern goshawk nests in New Mexico and Arizona during the nesting season (Chapter 1). Based on these results, results of other studies of the breeding biology of the northern goshawk in New Mexico (Kennedy 1988, Kennedy unpubl. data), and studies on woodland raptor survey techniques (Rosenfield et al. 1988, Devaul 1989, Titus 1990, Kimmel and Yahner in press) we have developed an inventory protocol for increasing the probability of locating northern goshawk nests in the Southwest Region, USDA Forest Service. Once nests are located they can be managed using appropriate techniques for territory maintenance or improvement. If this protocol is implemented properly, we think a large proportion of the northern goshawk nests can be located in the surveyed areas. However, there is not enough information currently to numerically estimate the expected proportion of the nesting population in the Region that will be located with any degree of confidence. To construct such an estimate, information is needed on the abundance of nesting northern goshawks in the various forest types in the region and the availability of these forest types throughout the region.

AREAS TO BE SURVEYED

The northern goshawk nests in coniferous forests throughout the western U.S. (Reynolds 1989). Kennedy (1988) found northern goshawk nests in many of the common montane habitat types in New Mexico. Within these habitats all nests were placed in the lower canopy of large diameter (X = 57.2 cm), ponderosa pine (Pinus ponderosa), aspen (Populus tremuloides), or Chihuahuan pine (Pinus leiophylla). In northern Arizona, Crocker-Bedford and Chaney (1988) also found northern goshawks nesting in the common montane habitats in that area. They identified good nesting stands as having at least 79% canopy closure, suitable stands had a minimum of 72% closure, and marginal stands had a minimum of 60% closure. In areas with a great deal of topographic relief, many of the nests are associated with drainages.

The habitats with the highest potential for nests in the southwest are ponderosa pine and mixed conifer stands with large trees (>50.8 cm dbh) with densities of 61 large trees/ha (Crocker-Bedford and Chaney 1988), e.g., uncut forests and drainages. In general, these areas correspond with U. S. Forest Service vegetative structural stages 5b through 6. When designing a survey, these habitats should be given top priority. To maximize the number of northern goshawk nests found in a short time period, we recommend that the emphasis of the 1991 and 1992 northern goshawk surveys conducted by the U. S. Forest Service should be to completely survey all of the stands with 5b - 6 vegetative structural stages in the southwest region for nest sites. This would include areas within timber sales as well as areas not currently included in sale boundaries.

However, because this raptor nests in a wide variety of forest habitats in the southwest including second-growth stands (Kennedy 1988), stratified sampling plans should be developed to survey other forest types for northern goshawk nests and these sampling plans should be implemented by the 1993 nesting season. Titus (1990) has an excellent review of stratified sampling in the design of raptor surveys and his points should be used in designing such a sampling scheme.

LOCATING NORTHERN GOSHAWK TERRITORIES

Types of Vocalizations Used in Northern Goshawk Surveys

As shown in Chapter 1, one way to increase the efficiency in locating northern goshawk nests is to imitate their calls. Upon hearing a suspected intruding conspecific, mate, or parent, many northern goshawks respond by approaching the source and/or vocalizing in response.

The northern goshawk has a varied repertoire of vocalizations (Palmer 1988). Many of these vocalizations could potentially be used to survey for northern goshawk territories under appropriate conditions. The results of a test of the effectiveness of 3 northern goshawk vocalizations under controlled experimental conditions is summarized in Chapter 1.

The 3 calls that elicit a response from nesting northern goshawks are: 1) the alarm call (*keck-keck-keck*), which is given by both adults during the nesting season and is directed towards a conspecific intruder or potential predator (Chapter 1, Kimmel and Yahner in press); 2) the wailing call, which is given by both adults, predominantly the female, and appears to be principally a means of communication between pair members, and 3) the begging vocalizations of the fledglings (Chapter 1). The begging call of the fledglings resembles a high-pitched version of the female's "recognition scream" when the male appears in the nest area. Both the wail and begging calls are one-note calls and have remote gull-like qualities (Palmer 1988). Tape recordings of these 3 calls are available from the Regional Office of the USDA Forest Service in Albuquerque, NM.

Based on the results presented in Chapter 1, we recommend using the alarm or kecking call for surveys of northern goshawk nests during the nestling period (late May - early July) and the wailing call during the fledgling-dependency period (July-early September).

Survey Method - Our results combined with the results of other investigators (see Chapter 1) indicated that a majority of adult northern goshawks during the nestling period may be detected when conspecific calls are broadcasted within 150 - 200 m of the nest. Therefore, to completely census a stand, we recommend that transects be spaced no more than 300 m apart and that taped kekking calls be played at broadcast stations spaced every 150 m along paced transects. Complete coverage of the area means that every portion of the survey area is within 150 - 200 m of a broadcast station.

Upon arriving at a calling station, the observer will stand quietly and listen for 1 minute. After 1 minute, s(he) will play 30 sec of the appropriate call, then repeat 10 sec of the call every 30 sec for 3 minutes. The caller will remain at the station for 1 minute after the last tape broadcast. Calls will be broadcast in the four cardinal directions in 10-sec time units. This is a total of 10 sec . The observer must continuously scan in all 360o since a silent respondent could approach from any direction.

If a northern goshawk vocalizes in response to a broadcast call, the observer should take a bearing from the calling station to the location of the responding vocalizations. If a visual sighting of a northern goshawk occurs, the observer should take a bearing on the visual observation and record the direction of the bird's flight path as it enters and departs the calling station. All of the response information should be recorded on a data form and on a map of the study area.

Sampling Periods

The results of this study (see Chapter 1) indicate that detection rates with vocalizations were highest during the nestling period when compared with other periods in the nesting season. As a result we recommend that all surveys be conducted with the alarm call during the nestling period (June - mid July). Each area must be covered a minimum of once during this period. If there is a reason to survey an area during the fledgling-dependency period (July - early September), e.g., to verify some inconclusive results collected in the nestling period such as a concern over false positives (see Chapter 1), the begging or wailing call should be broadcast at that time.

Recruitment rates of breeding adults appear to be low in some areas of the Southwest Region (Kennedy unpubl. data). If an adult loses its mate over the winter it may take two years for the bird to replace its mate. Though non-nesting adults may respond to broadcasts of goshawk calls (see Chapter 1), a territory could be missed if an area is only surveyed once during one breeding season. To adequately survey an area for northern goshawk territories, surveys should be repeated for a minimum of two years in a row.

Broadcasting Equipment

A sound level of 100-110 db, 1 m from the source is recommended (Devaul 1989), thus, equipment that can produce this sound intensity without significant distortion is necessary. Fuller and Mosher (1987) recommend using a portable cassette tape recorder that includes a frequency response of about 100 Hz to 10 kHz, a minimum power output of about 1.2 W at 1 kHz, and an output plug for an external 10-20 cm trumpet speaker (8 ohm) or a combination of amplifier and speaker.

Number of Observers on a Survey Crew

Based on the recommended survey method discussed above, one observer could complete a 2 km transect in approximately 2 hr. One observer walking a 2 km^2 area at 300-m intervals could cover this area in 12 hr. A crew of 6 people spaced at 300-m intervals on 6 different transects should be able to cover 1 km^2/hr in the field, or 8-12 km^2 during a long mid-summer day under ideal weather conditions (see section on Weather in this Chapter). Kimmel (pers. comm.) uses one 6-person crew to cover approximately 25% of an 83,000 ha (20,750 ha) study area in Alleghany National Forest in Pennsylvania during the nestling period. We recommend that crews of 5-6 persons be used to conduct surveys for nesting northern goshawks in the southwest region.

Qualifications of the Observers

The observers that conduct the territory surveys and nest searches minimally need to be able to visually identify northern goshawks in the field. The person must be able to correctly distinguish a northern goshawk from a forest-dwelling red-tailed hawk (Buteo jamaicensis) or female Cooper's hawk based on a 2-sec glimpse of a bird flying through the woods. The observer should also be able to sex and age class northern goshawks and be able to identify their vocalizations.

The ability to identify a variety of southwestern birds by their vocalizations would also be a useful skill for the observer and would improve the reliability of the data. As indicated in Chapter 1, Steller's jays will mimic northern goshawk vocalizations in response to broadcast vocalizations of northern goshawks. An inexperienced observer could easily record a Steller's jay mimicking an accipiter alarm call (see Chapter 1), or a variety of woodpecker calls as a northern goshawk response. If northern goshawks do not nest in the area this could result in many person-hours wasted looking for a nest that does not exist.

To reduce the inefficiencies of inexperienced observers, we recommend that all crew leaders be required to pass a northern goshawk identification seminar *before* initiating any surveys. These training seminars can be similar in design to the spotted owl (*Strix occidentalis*) training seminars currently being offered in the southwest region. We envision the crew leaders and District and Forest Biologists taking a 2-day seminar on northern goshawk identification in late May in Albuquerque. These people would then conduct a shorter seminar on the District for crew members. All crew members must pass a test similar to

the spotted owl test required of all personnel conducting spotted owl surveys.

Weather Conditions

The effect of weather conditions on the detectability of northern goshawks was not tested in this study. Without knowledge of these effects, surveys must be restricted to periods of good weather conditions. No surveys should be conducted during rainy or foggy conditions, although intermittent drizzle or mist is acceptable.

Winds of moderate to high speeds are common in mountainous areas during the early summer. High wind speeds interferes with the transmittal distance of the taped broadcast and the observer's ability to hear responding hawks. As a result, surveys should not be conducted when wind speeds exceed 25 km/hr or a Beaufort rating of 4. Early mornings are generally suitable survey conditions. The afternoon conditions will be more variable.

TYPES OF NORTHERN GOSHAWK RESPONSES TO THE BROADCAST VOCALIZATIONS

The northern goshawk can respond to the broadcast vocalizations in a variety of ways and the interpretation of these responses is dependent upon the observer's ability to sex and age class the responding hawk. The potential responses during the nestling period (when the surveys should be conducted) and their interpretations are discussed below.

Nestling Stage-Alarm Calls

Vocal response-no visual observation. If a northern goshawk responds to the tape with an alarm call (*keck-keck-keck*) or a wail, a northern goshawk territory has been located within the vicinity of the calling location and a nest is probably within 350 m of the calling location. All responses to kecking calls during the nestling period were within 316 m of the nest (Chapter 1). The direction of the calling bird is the most likely locale of the nest, but responses from directions other than the nest have been recorded (Kennedy and Stahlecker unpubl. data).

Vocal response and a visual observation. If the responding bird is identified as an adult female, an active northern goshawk nesting territory has probably been located. There is a high probability that an active nest is in close proximity (< 200 m) to the observer and is located in the direction of the calling bird.

If the responding bird is an adult male, an occupied territory has probably been located but the observer may be farther from an active nest. Adult males may vocalize at an intruder while on their hunting areas adjacent to the nest stand (Kennedy and Stahlecker unpubl. data). An active nest is probably within a 2-km radius of the observer.

If the sex of the responding bird is unknown, use the interpretation described above for the adult male.

Visual observation of a northern goshawk (no vocal response). A nesting adult may come to look at the "intruder" without vocalizing. If the responding bird is an adult female, a northern goshawk territory has been identified and an active nest may be within 350 m of the observer. The nest location is probably in the direction from which the bird approached the observer.

If the responding bird is an adult male, a hunting territory has been located but the location of an active nest cannot be pinpointed from this information. Adult males can hunt 5-10 km from the nest during the nesting season (Kennedy unpubl. data), particularly if the nest is in marginal habitat. Additional information is needed from other surveys or nest searches before a nesting territory can be delineated.

If the sex of the responding bird is unknown, use the interpretation described above for the adult male.

LOCATING THE ACTIVE NEST

The purpose of the vocalization surveys is to minimize the area that needs to be searched on foot to pinpoint an active nest. Tapes are only to be used to locate nesting territories. To find the active nest, thorough searches of the identified nesting territory must be conducted. Once an adult female has responded to the tapes, do not play the tapes again to locate the nest. The birds may habituate to the tapes and their responsiveness to the tapes could decline dramatically after the first exposure (Kennedy and Stahlecker unpubl. data). Additional broadcasts could negatively affect future surveys. In addition, continual playing of the tapes constitutes a disturbance and could result in an impact to normal nesting activities.

Once a nesting territory has been located, as a result of the surveys or repeated sightings of northern goshawks noted during other field activities, the habitats with the highest potential for nesting should be searched first. These areas include any drainages with large dbh (> 50 cm) trees or uncut stands with large trees. If a nest is not located in these areas, the less suitable habitats should be searched thoroughly.

Nest searching requires one or more personnel (preferably the entire 5-7 person survey crew) walking through the potential nesting territory for 2-3 hr looking for signs of nesting. These signs include, stick nest structures (45-90 cm in diameter and 25-50 cm deep), plucks of avian and mammalian prey located under suitable plucking posts, molted northern goshawk feathers, and an abundance of raptor mewt near nest structures or under potential perches, e.g., large dead snags.

During the nestling stage, the adult female usually perches near the nest. Many female northern goshawks "assist" with nest finding by exhibiting extreme defensive behavior when an observer is near a nest, e.g., loud alarm calls combined with stoops directed at the observers. In fact, searchers should be alert for their own safety because the female may attack silently from the rear. However, some females will perch quietly out of view and are not easily detected during nest

searches. If an adult female is present and acting defensively, she is probably within 100 m of the nest.

CHAPTER 3

A PROTOCOL FOR LONG-TERM MONITORING OF NORTHERN GOSHAWK TERRITORIES

Northern goshawk nest sites should be monitored annually to insure their continued productivity. This chapter briefly describes a protocol for long-term monitoring of northern goshawk nesting territories.

COURTSHIP PERIOD (APRIL)

Conduct 1 or 2 visits to the previous year's nest stand during April. Sit quietly 2-300 m from nest, listen for vocalizations (do not be fooled by jays) and watch for flying adults. Each visit should be 2-4 hours long and occur between 1 hour after sunrise and noon. If two nest stands are less than 500 m apart, sitting quietly midway between them should allow simultaneous coverage. Two nest stands in relative proximity (whether or not in the same territory) can be visited 2+ hours each in the same morning; reverse the order of visits on the second morning. DO NOT play any goshawk tape at the nest. There is some evidence broadcasts at this time can interrupt courtship.

Auditory or visual confirmation of adult goshawks confirms occupancy of the territory. Activity concentrated in a particular area is indicative of the preferred nest site. Do not visit the nest stand unless it is necessary to confirm the identity of a calling bird. Limit such a visit to < 5 minutes.

If no goshawks are seen or heard after 2 visits, briefly (< 15 min) visit all known nest trees. Check the nest platforms for new construction, and especially for fresh greenery (twigs with green needles) on the top of the nest. If there is another nest stand within the same territory but > 500 m from the previous year's nest, repeat the quiet visitation procedure.

NESTLING PERIOD (June 15 to July 15)

Situation 1: Adult(s) present in a nest stand in April.

Return to that nest stand and search for an active nest (see Chapter 2, LOCATING THE ACTIVE NEST). Document productivity, if possible. If young are too small to be seen from the ground, return when young will be larger and easier to count. If unsuccessful, check other known nest stands within the territory in the same manner. If still unsuccessful, move to Situation 2.

Situation 2: No adult(s) present at any nest stand in the territory in April.

Revisit all known nests within the territory. Check for evidence of occupancy (see Chapter 2 - LOCATING THE ACTIVE NEST). Document

productivity, if possible. If there is no evidence of activity at any known nest, conduct a broadcast survey with the adult alarm call (See Chapter 2) in all suitable habitats within 2 km of the previous year's nest.

FLEDGLING PERIOD (July 15 to August 15)

Situation 1: Successful nest

Determine the number of young fledged from the nest.

Situation 2: Still no evidence of breeding this season.

Conduct a broadcast survey with the wailing call or the begging juvenile call (See Chapter 2) in all suitable habitat within 2 km of the previous year's nest.

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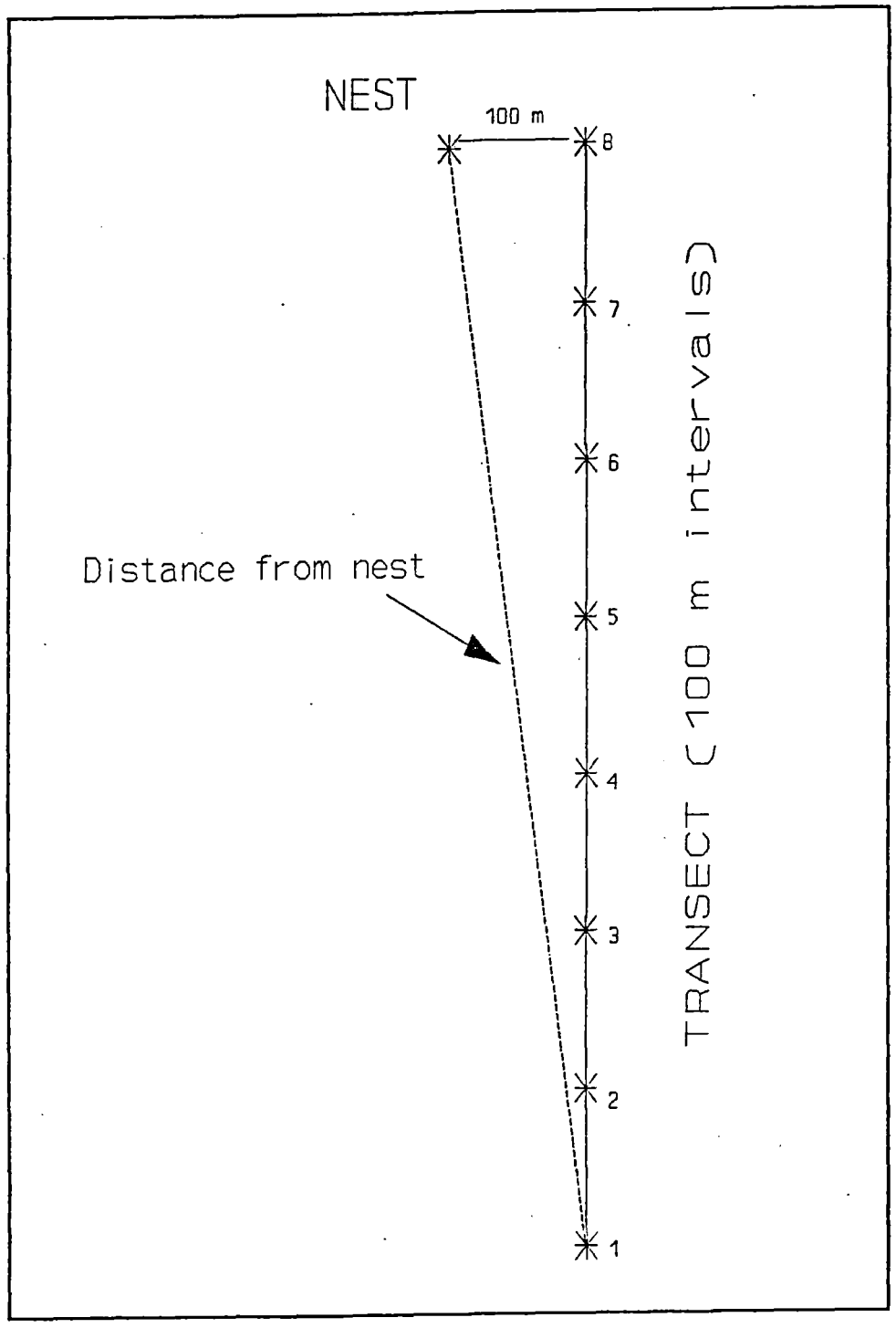

Figure 1. Diagram of the transect design used to test the effectiveness of broadcast vocalizations in detecting nesting northern goshawks.

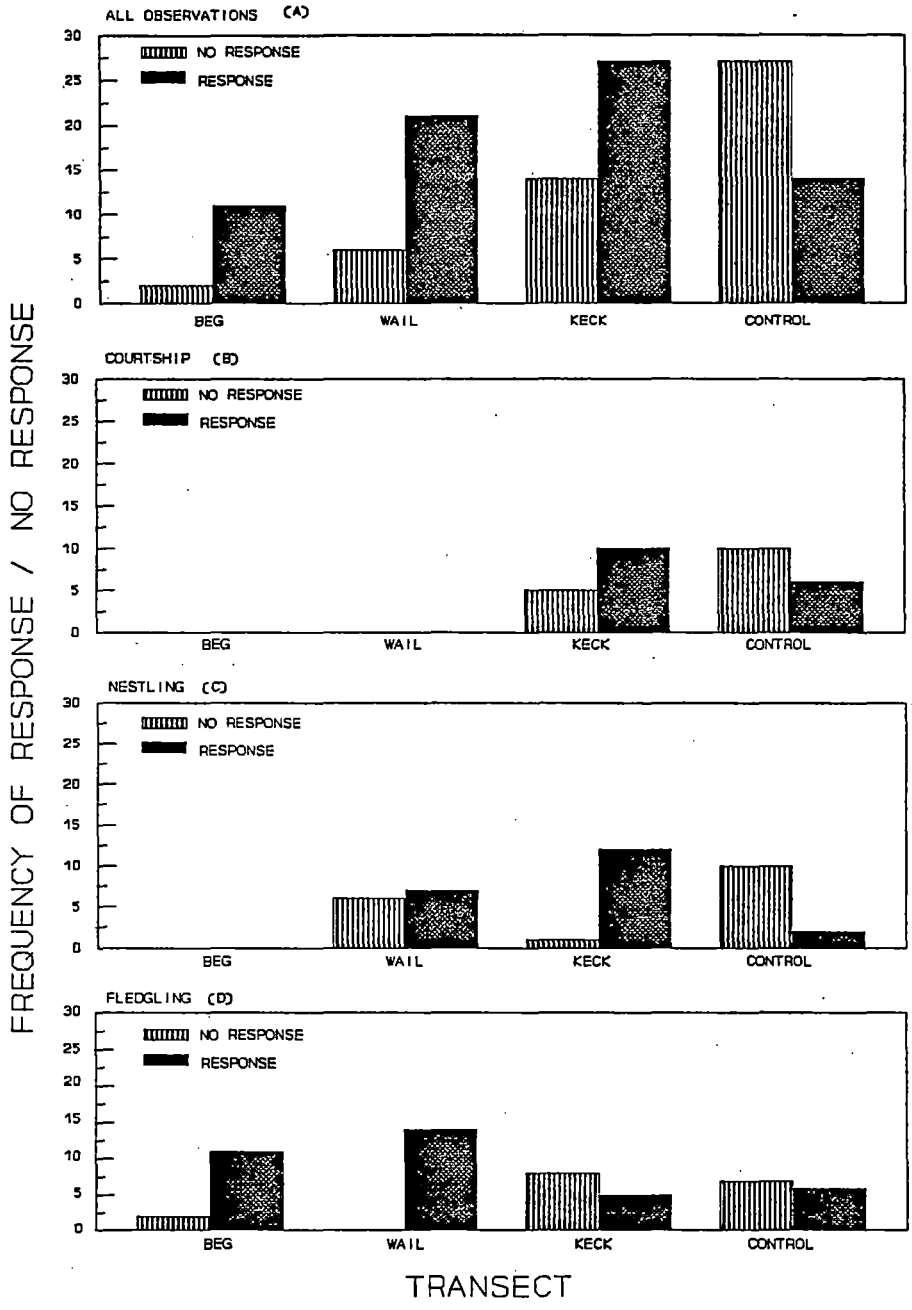

Figure 2. Frequencies of responses and no responses of northern goshawks at successful nests during control and vocalization transects. Frequencies for each type of transect are presented for all sampling periods (A), the courtship period (B), the nestling period (C), and the fledgling-dependency period (D). The begging vocalization was only used during the fledgling-dependency period and the wail vocalization was not used during courtship.

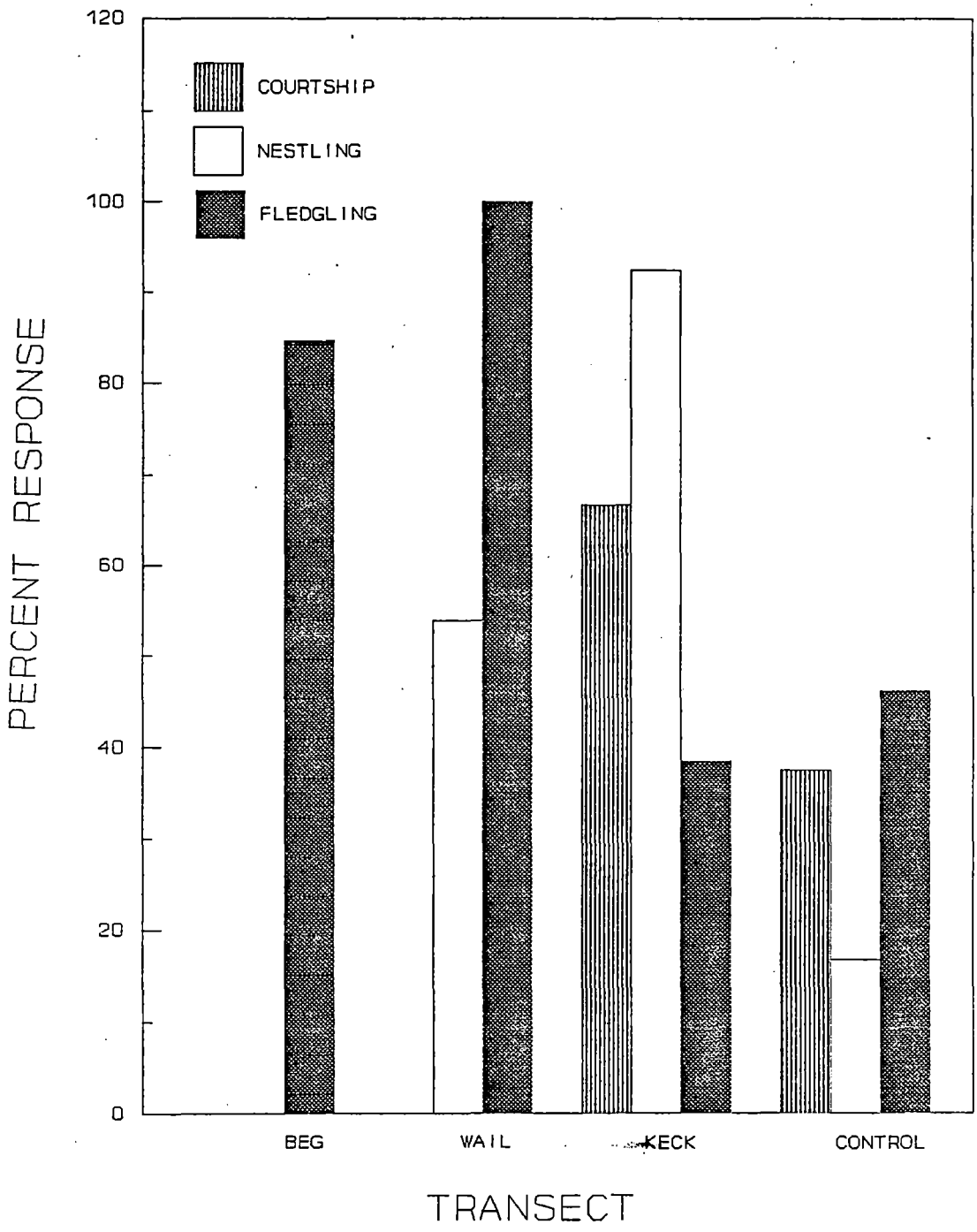

Figure 3. Percentage of responses by northern goshawks to taped vocalizations and observers without tapes (control transect) for each sampling period.

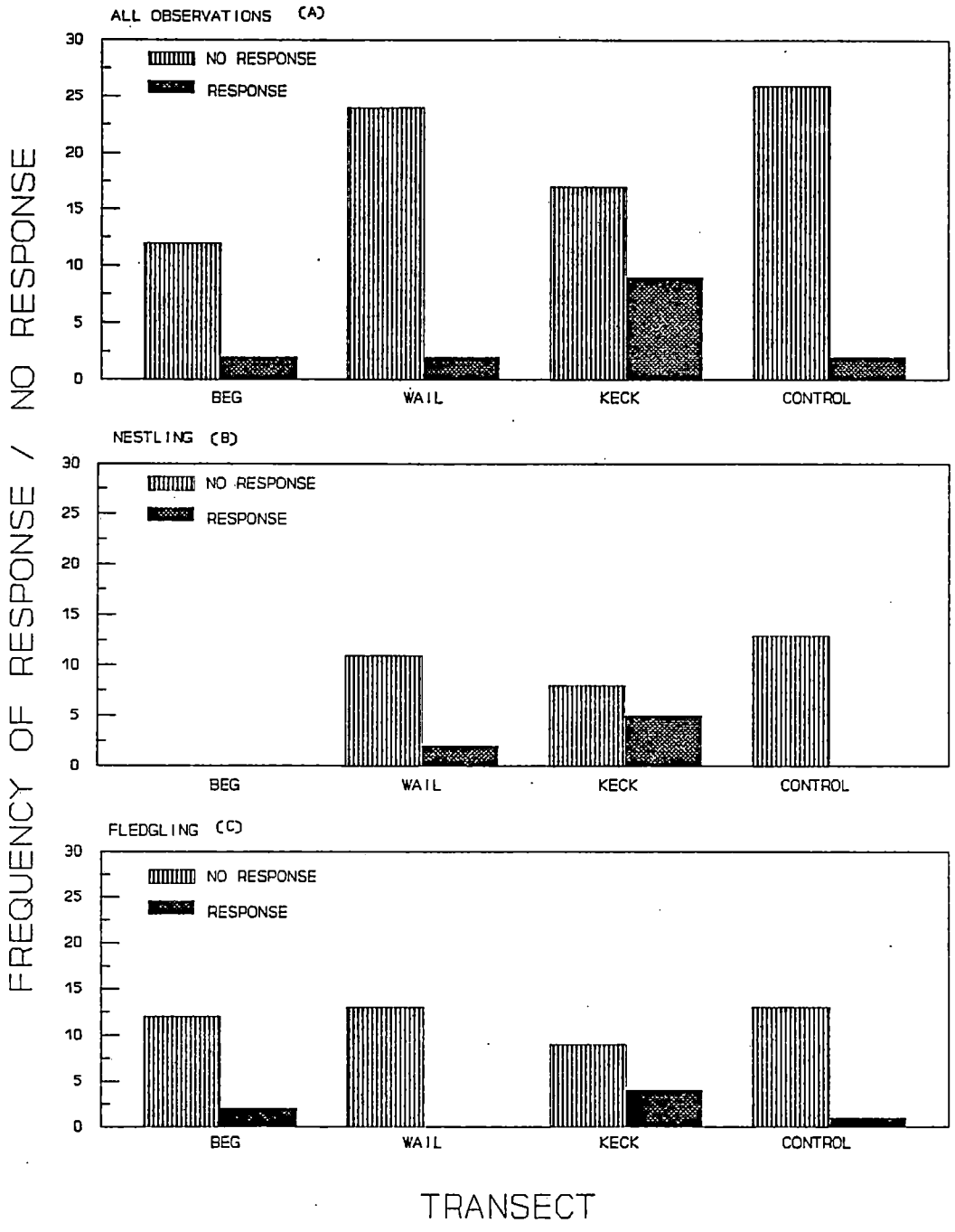

Figure 4. Frequencies of responses and no responses of northern goshawks at unsuccessful nests during control and vocalization transects. Frequencies for each type of transect are presented for all sampling periods (A), the nestling period (B), and the fledgling-dependency period (C). All nests were active during courtship. The begging vocalization was only used during the fledgling-dependency period and the wail vocalization was not used during courtship.

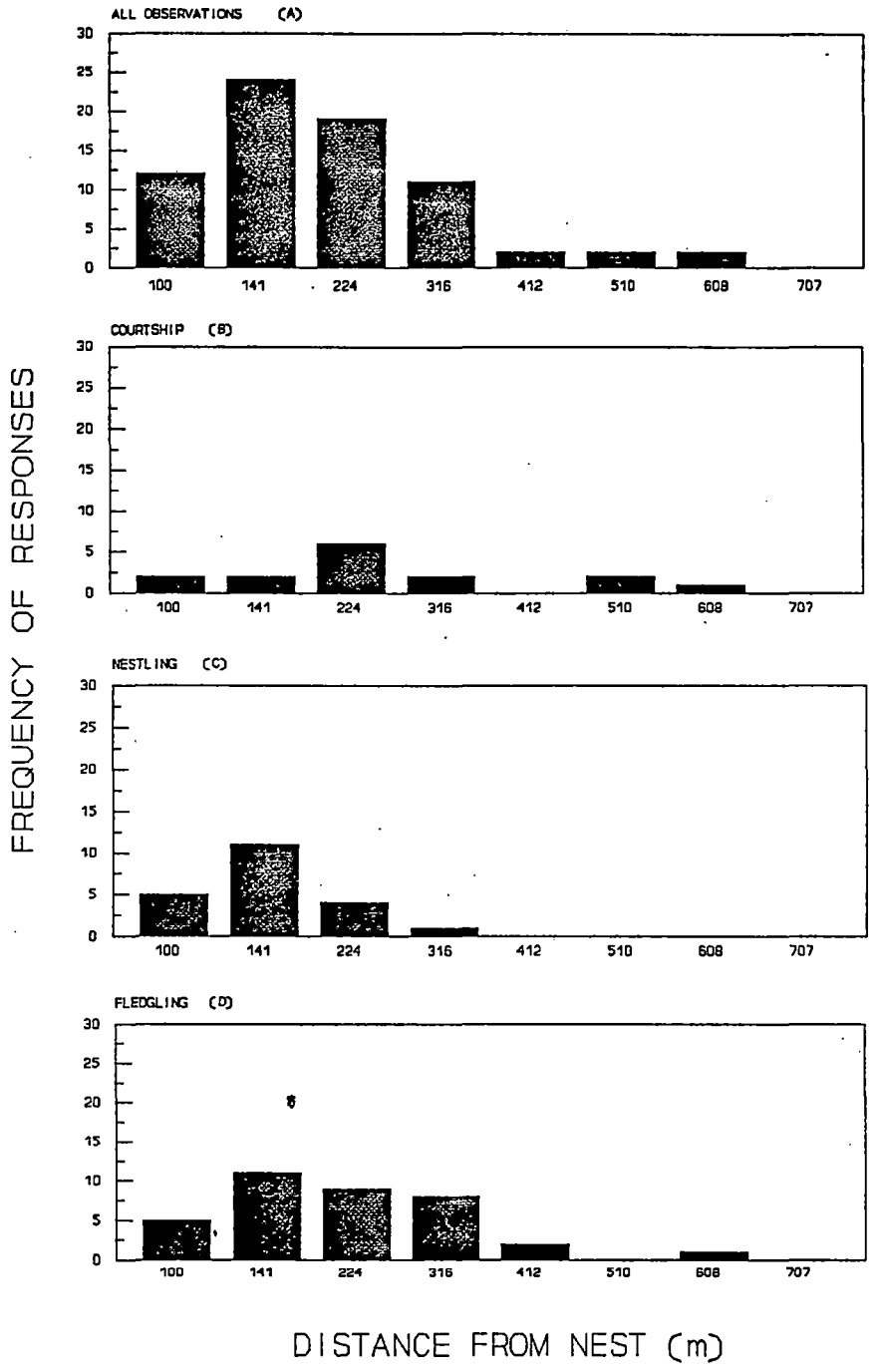

Figure 5. Frequency of northern goshawk responses at successful nests as a function of distance (m) from the nest during all sampling periods (A), the courtship period (B), the nestling period (C), and the fledgling-dependency period (D). Data from control and vocalization transects are pooled in this figure. The distance categories represent the distance of each station from the nest.

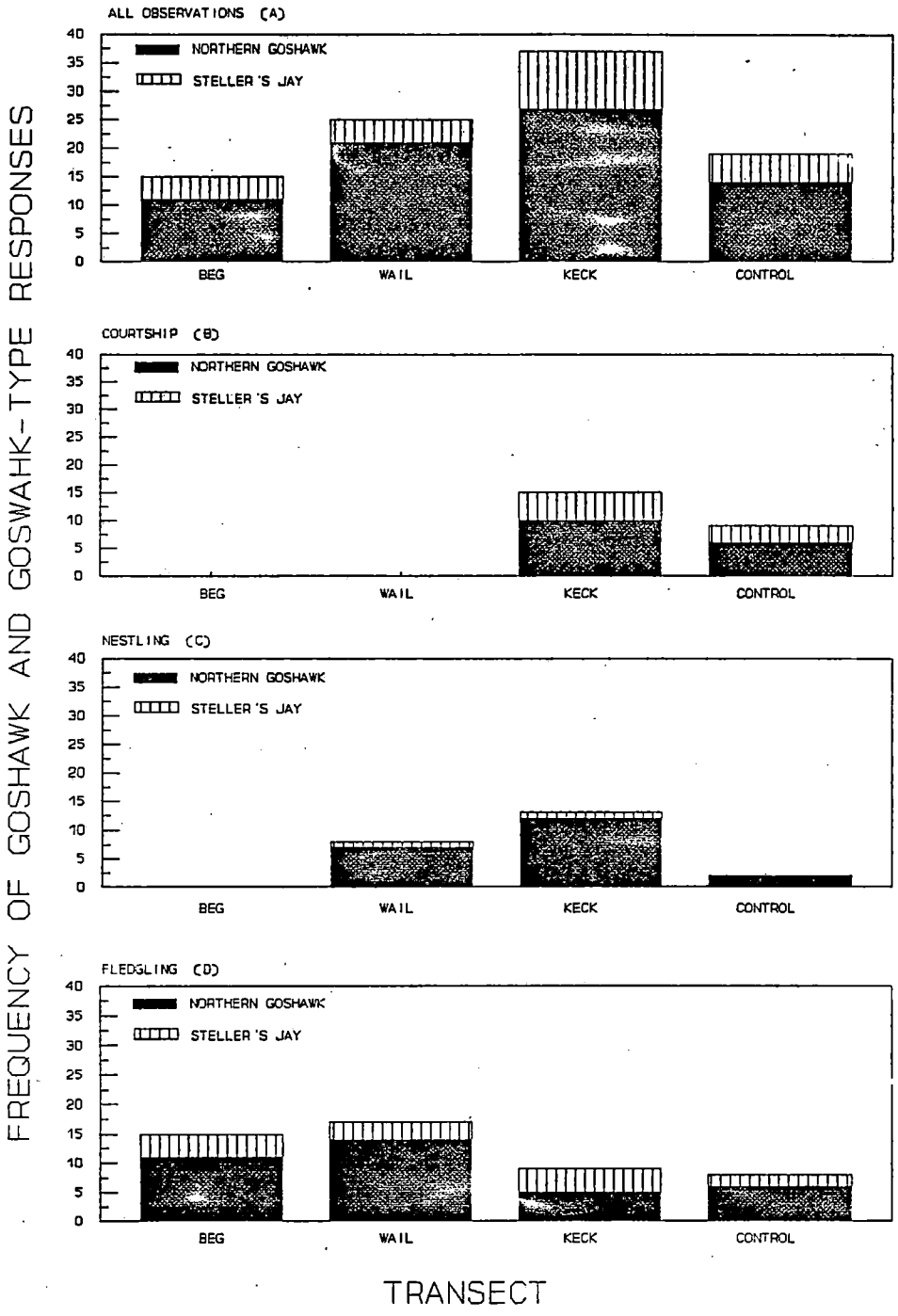

Figure 6. Frequency of northern goshawk responses and goshawk-type responses from Steller's jays at successful nests during control and vocalization transects. Frequencies for each type of transect are presented for all sampling periods (A), the courtship period (B), the nestling period (C), and the fledgling-dependency period (D).